Antennas & Things

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SIMPLE ANTENNAS AND ACCESSORIES FOR SIGNAL IMPROVEMENT

Using Filters To Improve Your Receiver — Part 1

There is a hill not too far from me where radios are surely tested. I first experienced this hill when a friend of mine got his ham license and lived only a block from the site. This hilltop (actually, "bumptop" is more like it) has a 2,000-watt AM BCB station, two 50-kW FM BCB stations, and a microwave relay tower with scads of antennas on it. Not helping things much are the scores upon scores of two-way landmobile radio antennas. It seems that landmobile and cellular operators rent space on radio station towers to gain the height they need.

So what? Doesn't that just give you a signal-rich environment? Absolutely NOT! The problem is that your receiver can only handle a certain amount of radio frequency energy in its front-end. That area of the receiver is not a very narrow band, so signals wander through that might not otherwise make it. Indeed, even if your front-end is tuned (usually with an "antenna tune" or "preselector" control), the bandpass is quite broad. Receivers with an untuned front-end may use a bandpass filter, which is still a bit of a problem.

The offending signal need not be in the same band as the signal being sought. The offending signal may be out of band and not even heard on the receiver. If it gets to the RF amplifier or mixer, then it may take up enough of the receiver's dynamic range to make your receiver less sensitive.

Another manifestation is that the offending signal may cause harmonics of itself to be generated. Those harmonics are valid signals, so the receiver will tune them in as if they arrived on the antenna. The problem is that the *undesired signal* drives the receiver front-end into a nonlinear operating region, which has the effect of increasing harmonic distortion.

Still another problem caused by letting strong out of band signals reach the receiver is the creation of intermodulation products. When two signals are present, and are able to drive the front-end circuitry of the receiver into nonlinearity, then a batch of new frequencies is generated. After all, the front-end contains a mixer, and if it hits the radio frequency amplifier first, it can make that stage pretend it's a mixer. The frequencies generated are defined by mF1 (nF2, where m and n are integers (0, 1, 2, 3, . . . N). These frequencies are:

F1 + 2F2 Third order products
F1 - 2F2
2F1 + F2
2F1 - F2
2F1 + 3F2 Fifth order products
2F1 - 3F2
3F1 + 2F2
3F1 - 2F2

So what does this mean? Suppose you live near an AM broadcast band station that is operating on 1500 kHz. Suppose a reasonable local ham operator starts broadcasting on a frequency of 7200 kHz. These frequencies will provide third and fifth order intermod products of 4200 kHz, 9900 kHz, 10200 kHz, 12900 kHz, 15900 kHz, 18600 kHz, 18900 kHz, and 24600 kHz. Note where those intermodulation products fall? Right in the middle of some of your listening territory. And when you count the fact that the ham operator can operate over a 300-kHz portion of the band from 7000 to 7300 kHz, there is actually a wide area 200 kHz below and 100 kHz above those spot frequencies that are vulnerable.

Now calculate what happens when the ham changes bands! Can it still get worse?

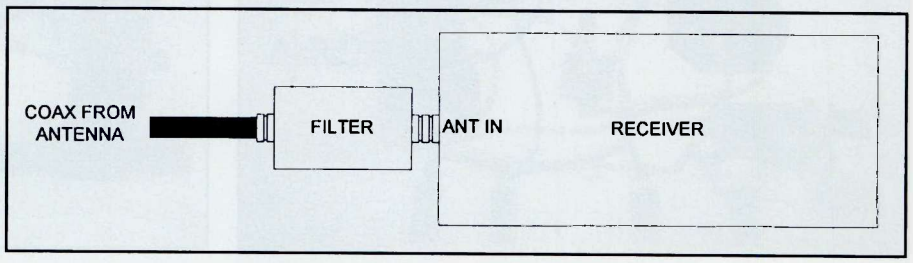


Figure 1. Mounting the filter to a receiver.

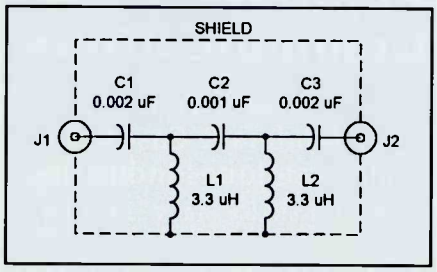


Figure 2 . Simple filter to rid an SW receiver of AM BCB QRM.

Yep, it sure can. Keep in mind that AM BCB stations tend to have two endearing qualities that help them mess up your shortwave reception: 1) they are local, so their strength is very high at your location, and 2) they are high powered (250 watts to 50 kilowatts). As a result, there is a huge signal from that AM BCB station.

The Solution

So what's the solution? In all of the cases mentioned above, there is one solution that works best of all: *prevent the offending signal from entering the receiver.* Whether the problem is desensitization from front-end overload, harmonic generation, or intermodulation, the solution is to get rid of the bad signal. In the case of intermodulation products, getting rid of just one of the two signals is all that's needed. A filter in the antenna line ahead of the receiver will work nicely for this purpose.

Installing The Filter

Figure 1 shows the installation of the filter. The filter is built inside a shielded box (any other construction for an external filter is basically a waste of time) with coaxial connectors on either end. Simple filters are bidirectional, so it doesn't matter which coax connector is used for the receiver and which is used for the antenna. Next time, we will look at a more complex "killer" filter that is not bidirectional, so it matters a lot which coax port goes to which part.

The input side of the filter is connected to the coaxial cable from the antenna using a PL-259/SO-239 connector pair (or some other type of connectors if your receiver

is different from most). The female coax output of the filter and the female coaxial antenna input (ANT IN) on the receiver are connected to each other with a double-male PL-259 UHF connector.

If you can't spare the room on the back of the receiver for a big clunky box, then use a short piece of coaxial cable between the filter output and the antenna input. However, this is second best and, if done, the cable should be as short as possible. The problem is pick-up of the filtered signal in the line. If coax were perfect, then that wouldn't happen. But guess what?

A Simple Filter

Figure 2 shows a simple AM BCB filter I've been using for many years. I first saw this design in a 1960s vintage Bill Orr (W6SAI) *Radio Handbook*, and it's been repeated in a number of ham magazines (often without attribution to Bill). This filter is a simple pi-section (so-named because of its resemblance to the Greek lower case letter π) filter, designed for 50 ohms input and output impedances. The cut-off frequency is about 2000 kHz, just at the lower end of the shortwave bands.

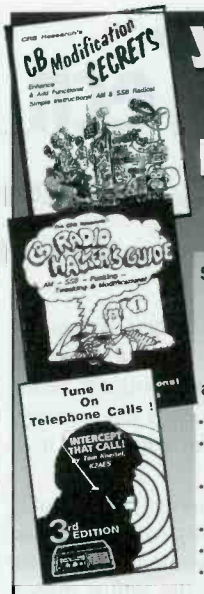
The nice thing about this little filter is that it uses some easily obtained components. The capacitors, for example, are standard values. The best capacitors to use are polyethylene types. You will find these rated in picofarads, so keep in mind that 0.002 (F) is 2,000 pF, and 0.001 (F) is 1,000 pF. If you can't get the polyethylene capacitors, then silvered micas will do almost as well. The highest easily obtained value is 1,000 pF, so connect two in parallel for each 0.002 (F) capacitor.

The inductors are also easily obtained. If you look in catalogs, such as Digi-Key's and other mail order suppliers, then you will find several 3.3 (H) offerings. If push comes to shove, then you can also wind some toroid core coils. Use the T-50-15 (RED/WHITE) core, and use 16 turns of enameled insulation wire (#26 AWG to #30 AWG).

If your problem is not too severe, then this filter works fine (build it inside a shielded box)! In fact, it may work spectacularly well if you have a moderately severe problem.

Next Time

In the concluding part of this two-part series of "Antennas & Things," we will take a look at a few more filter designs, including one that will protect your AM BCB receiver from the dirty, smelly, bad guys in other bands. ■



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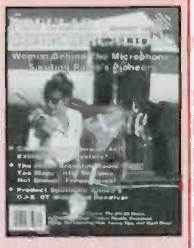

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Antennas & Things

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SIMPLE ANTENNAS AND ACCESSORIES FOR SIGNAL IMPROVEMENT

Using Filters To Improve Your Receiver — Part 2

Last time this column appeared in *Pop'Comm,* we discussed the general problem of ridding receivers of AM BCB interference. Simply stated (or restated if you read Part-1), the problem is that strong, local stations tend to overpower radio receivers.

Not only are they very close because that's what "local" means (which would be problem enough), but they are also high-powered. The blowtorch "clear channel" stations operate at 50,000 watts of output power, while even the dinkiest local breath-of-hot-air-type station operates with 250 to 500 watts. Power levels of 1,000 to 10,000 watts are common. One chap measured 4 volts peak-to-peak (that's 4,000,000 microvolts) of RF signal across a 50-ohm dummy load resistor connected to the receiver end of his antenna coaxial cable. Want to guess how much signal arrives in the form of shortwave stations? Try a few *microvolts*!

That, then, is the crux of the monitor's problem. When we live near AM or FM broadcast stations, we need to be able to eradicate the offending signal *before* it gets into the receiver.

Last time, we took a look at how filters are mounted. The correct mounting is between the antenna coax and the antenna input of the receiver. If possible, the filter should be mounted on the back of the receiver, directly to the antenna input coaxial connector without any coax between them (a double-male connector will do this for you). If absolutely necessary, then use a short — repeat, short — piece of coax between the output of the filter and the antenna input of the receiver.

Also covered last time was a simple pi-section filter that will snuff out the AM BCB energy well enough for all but the most severe cases. It used readily available components, so it had a certain charm that compensated for its generally low attenuation slope.

In this month's column, we will look at a superior AM BCB filter with up to 36 dB/octave attenuation, a filter to protect AM BCB receivers from other signals, and a special coaxial cable filter that will help VHF/UHF scanner operators get rid of interference from FM BCB (88–108 MHz) stations, some TV stations, and all-too-local landmobile stations.

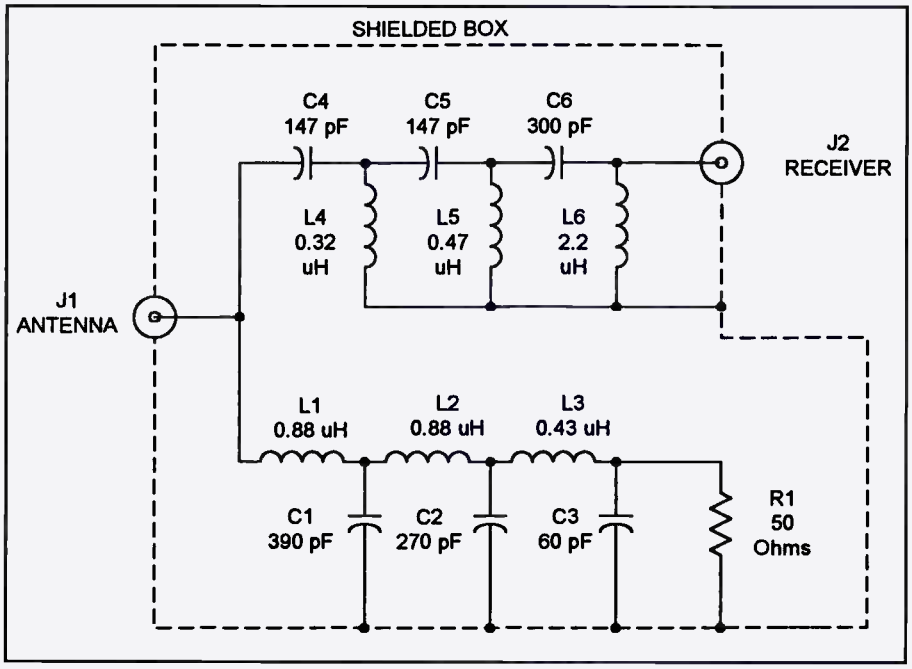

Figure 1: AM BCB absorptive filter.

Absorptive AM BCB Filter

The type of filter shown last month is typical of most filters. It is called a **reflective filter** because the energy of the rejected signals is reflected back towards the source. Those filters work reasonably well when the impedances at either end are reasonably constant and resistive. Unfortunately, most of the time the impedances are not so well-behaved. In those cases, or where more attenuation is needed, an **absorptive filter** is needed.

Figure 1 shows the circuit for an absorptive filter with a cut-off frequency of 2,000 kHz. These filters consist of two filters, actually. One filter is a high-pass type that passes all signals above 2,000 kHz arriving at the antenna connector (J1) to the receiver (J2). The other filter is a low-pass filter with exactly the same cut-off frequency (2,000 kHz in this case). It passes all of the signals rejected from the receiver filter and passes them to a 50-ohm dummy load, where they are absorbed, rather than reflected. For receiver purposes, a 51-ohm carbon composition or metal film resistor will do the trick. Alternatively, you can use two 100-ohm resistors of those same types connected in parallel.

The capacitance values are a little odd in a couple of instances, although most are standard. To make the 60-pF, connect a 33-pF and a 27-pF in parallel. A pair of 150 pF capacitors will make the 300-pF value, while a 100-pF paralleled with a 47-pF will work for 147-pF.

The inductors can be made using T-50-15 toroid powdered iron cores. The winding instructions are:

L1	8 t
L2	8 t
L3	6 t
L4	5 t
L5	6 t
L6	13 t

All of these windings should be with enamel insulation #26 AWG to #30 AWG

". . . it will do a good job of taking out FM BCB QRM."

wire. As with all such filters, construct this one inside a well-shielded metal box.

Blasting FM QRM From Scanners

If you operate a VHF/UHF scanner receiver anywhere near another transmitter, especially a high-powered FM BCB transmitter, then you will find it may suffer the same problems as the shortwave receiver near an AM BCB station. One of the most effective ways to eliminate this problem is to connect a series resonant wavetrap across the antenna input of your receiver. You can even buy such filters in video stores (intended for TV receivers). But the method of **Figure 2** can be home-brewed easily from an old scrap of coax.

The impedance connected to the end of a piece of coaxial cable repeats itself every half wavelength. Thus, a short circuit across the end, will reflect a short circuit for any frequency at which the length is half wavelength, or an odd integer (3, 5, 7) multiple of half wavelength. While this form of stub will also suck-out certain higher frequencies, it will do a good job of taking out FM BCB QRM.

The length of the coax stub is: inches

Where: F_{MHZ} is the frequency (in MHz) of the offending signal, a V is the velocity factor of the coax used to make the stub. The value of V is 0.80 for polyfoam coax, and 0.66 for old-fashioned polyethylene coax. Therefore, for a FM station at 104.5 MHz, and polyfoam coax, the length should be 5,952 (0.80)/104.5 = 45.5 inches.

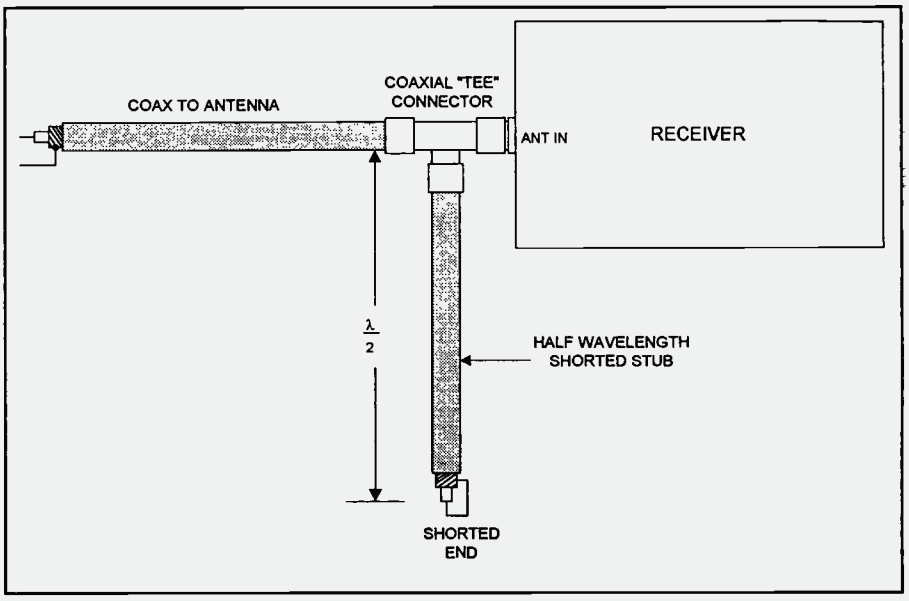

Figure 2: FM BCB coax stub filter.

Filter To Protect AM BCB Receivers

OK, now let's look at the inverse of the AM BCB problem. Suppose you are an AM BCB DXer, and want to keep shortwave signals (hams?) from interfering with the sensitive reception of your AM BCB signals. The filter in **Figure 3** is just such a filter. It consists of two filters in cascade: a 2,000-kHz low-pass filter, and a 500-kHz high-pass filter. It will suppress frequencies that are not in the 500- to 2,000-kHz region. If a ham on 7,200 kHz is normally causing some problems, then you may well find that this filter will do the trick.

So what if it doesn't help? Well, there are two possibilities. One is that the dude is so close that nothing is going to help. The other is that it is not an antenna-arriving interference signal. The offending signal can arrive by speaker leads in some cases. In other cases, the shielding of the receiver is so darn poor that RF pours into the rig from every joint and corner in the box.

I hope you find this material useful. And as always, if you have any comments or suggestions, drop me a letter. I can be reached by mail at P.O. Box 1099, Falls Church, VA, 22041, and via E-mail at <carrjj@aol.com>. ■

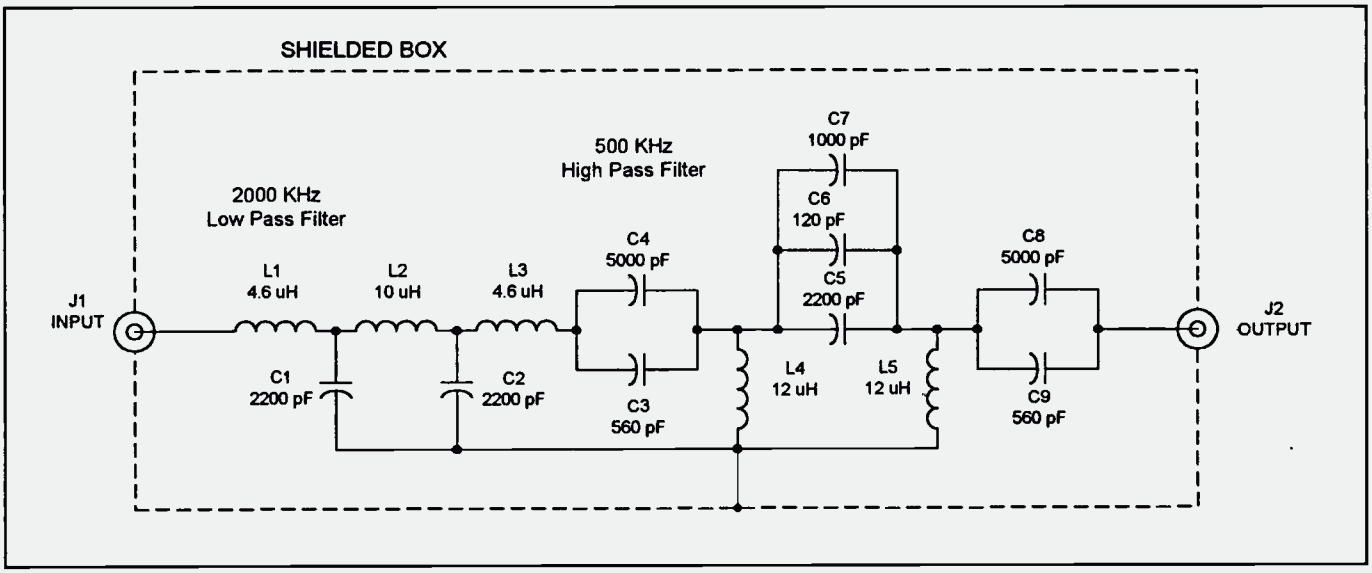

Figure 3: AM BCB bandpass filter.